

**PATENT APPLICATION**  
**Attorney Docket No. D/99423Q**

**APPLICATION FOR**  
**UNITED STATES LETTERS PATENT**

**To Whom It May Concern:**

Be it known that I, Dennis L. Venable, citizen of the United States of America and residing at Marion and State of New York, have invented an improved:

**DETECTING OVERLAPPING IMAGES IN AN AUTOMATIC IMAGE  
SEGMENTATION DEVICE WITH THE PRESENCE OF SEVERE BLEEDING**

**DETECTING OVERLAPPING IMAGES IN AN AUTOMATIC IMAGE  
SEGMENTATION DEVICE WITH THE PRESENCE OF SEVERE BLEEDING**

This invention relates generally to detection of a particular  
5 images of several documents placed on the platen of an image input device in  
the presence of severe background bleeding, and more particularly to the  
automatic detection of the overlap of a series of images placed on the platen  
using the technologies of joining orphaned images, linear regression  
algorithms and collinearity detectors.

10 Cross reference is made to the following related applications are  
hereby incorporated by reference for their teachings:

"METHOD AND APPARATUS FOR IDENTIFYING A PLURALITY  
OF SUB-IMAGES IN AN INPUT IMAGE," Dennis L. Venable et al., Application  
No. 08/786,538, filed January 21<sup>st</sup>, 1997;

15 "STRUCTURED IMAGE (SI) EDITOR AND METHOD FOR  
EDITING STRUCTURED IMAGES," Michael R. Campanelli et al., Application  
No. 08/338,856, filed November 14, 1994; and

"LOCATING THE POSITION AND ORIENTATION OF MULTIPLE  
OBJECTS WITH A SMART PLATEN," Dennis L. Venable., Application No.  
20 08/785,109, filed January 21<sup>st</sup>, 1997.

"AUTOMATIC IMAGE SEGMENTATION IN THE PRESENCE OF  
SEVERE BACKGROUND BLEEDING," Dennis L. Venable, Application No.  
D/99423, filed \_\_\_\_\_, 1999.

## **BACKGROUND AND SUMMARY OF THE INVENTION**

To improve the ease of use of scanning systems, in particular digital copiers and scanners, it is desirable to automatically detect and segment scanned objects (e.g., a hard copy document) on the platen of the input scanner. To facilitate this automated detection and segmentation, it is necessary to identify the position, shape and rotation angle of the object. Such a capability can enhance productivity by decreasing the time required for scanning documents, enable multiple images to be efficiently scanned and reduce the requirement for accurate presentation placed upon document feeding mechanisms.

The present invention is directed to a system intended to automatically determine the boundaries and overlap of multiple objects within a scanned image of a series of documents. The present invention combines a number of graphics and image processing techniques into an automated, system that provides productivity enhancement for digital copiers and scanning systems.

The present invention accomplishes these objectives by: 1) locating each of the objects within an input image; 2) modeling the shape of the identified object (e.g., rectangle); and 3) positioning the object in a digital image at a predefined locations.

Heretofore, a number of patents and publications have disclosed segmentation and detection, the relevant portions of which may be briefly summarized as follows:

US-A-5,485,568 to Venable et al., issued January 16, 1996, and hereby incorporated by reference, discloses a method and apparatus for representing a complex color raster image as a collection of objects in a structured image format - a hierarchical, device-independent format. A structured image document, generated using the techniques described by Venable, is a representation of data that may be rendered into a raster image.

The data includes simple raster images as well as a hierarchical collection of sub-objects and raster processing operations. The possible data types for objects in the structured image include a raster image, text, graphics, image processing description, and files containing multiple image representations

5 US-A-5,528,387 to Kelly et al., issued June 18, 1996, teaches electronic image registration in a scanner. In particular, the edge data of a document is detected and skew angle calculated. The image is then rotated based upon the skew angle and non-image areas are filled using an image generation feature.

10 US-A-4,922,350 to Rombola et al., issued May 1, 1990, discloses a two-pass scanning apparatus for detecting the size and position of an original document on a scanner platen. Image signals captured on a first scan are employed to determine boundaries and a best-fit magnification so that the image may be fit to a recording sheet using image signals generated on a  
15 subsequent scanning pass.

US-A-5,253,765 to Moorehead et al, issued Oct. 19, 1993, teaches a system for sorting randomly sized objects (e.g., mushrooms). Invariant moments are employed, utilizing the complete pixel information for all pixels within the border of a captured image, to extract information about the  
20 mushroom size and orientation.

US-A-5,220,398 to Horn et al. teaches an analog VLSI microchip that uses moments to determine the position and orientation of an object in a scene.

In "Invariant Fitting of Planar Objects by Primitives," published in  
25 *1996 IEEE Proceedings of ICPR '96*, pp. 508-512 Voss et al. teach a method of pattern recognition using primitives such as triangles, rectangles, circles ellipses, super-quadratics, etc. The authors further describe a technique for describing the primitives using moments in a normalized manner; resulting in a decrease in the numerical effort.

In "MANAGING AND REPRESENTING IMAGE WORKFLOW IN PREPRESS APPLICATIONS", *Technical Association of the Graphic Arts (TAGA)* Vol. 1, 1995 Proceedings pp. 373-385, hereby incorporated by reference for its teachings, Venable et al. teach the use of structured images to  
5 manage workflow.

In accordance with the present invention, there is provided a method for processing multiple digital images using an imaging input device so as to reduce bleeding of edges of the multiple digital images by determining the boundaries of each of the digital images, comprising:

- 10 detecting a boundary of a first image;
- detecting a boundary of a second image;
- determining an overlap between the detected boundaries of the first image and second images;
- calculating the overlap between the first and second images; and
- 15 modeling a third image from the calculated overlap of the first and second images wherein the third image contains at least said first and second images and represents a depiction of said first and second images without an overlap between said first and second images.

A method for processing multiple digital images using an imaging input  
20 device so as to reduce bleeding of contour edges of the multiple digital images by generating an object defined by contour edges of particular sets of the multiple digital images, comprising:

- detecting a set of edges of a first object;
- detecting a set of edges of a second object;
- 25 determining an overlap between the detected set of edges of the first and second objects;
- calculating the overlap between the set of edges of the first and second objects; and
- modeling a third object by ascertaining the calculated overlap of
- 30 the first and second objects wherein the third object contains at least said first

and second objects without an overlap of the set of edges of the said first and second objects.

The techniques described herein enable a user to expediently scan a document or other object, automatically recognizing the shape of the document within the digitized image, and composing a digital document incorporating the object.

The techniques described above are advantageous because they improve the efficiency of a scanning process, in the presence of severe bleeding.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is an illustration of an exemplary digital color printing system serving as an embodiment for the present invention;

Figure 2 is a block diagram of the various components comprising the system of Figure 1;

Figure 3 is an illustration of the placement of a document object on a platen of the scanner depicted in Figure 1;

Figure 4 is a flowchart illustrating the general processing steps carried out on the system of Figures 1 and 2 in accordance with the present invention;

Figure 5 is a detailed flowchart illustrating a series of processing steps carried out to initially determine the "seed" of the images;

Figure 6 is a more detailed flowchart showing the steps of determining the "seed" of the images.

Figures 7 is a detailed flow chart illustrating series of processing steps carried out in accordance with the present invention;

Figure 8 is an illustration of line estimation in accordance with the present invention.

Figure 9 is an illustration of a bin categorization in accordance with the present invention.

Figures 10A, 10B, and 10C are illustrations of a bin removal operation in accordance with the present invention.

Figure 11 is an illustration of a midpoint averaging between bins in accordance with the present invention.

5           Figure 12 is a detailed illustration of a step of the flowchart of Figure 6 in accordance with the present invention.

Figure 13 is a detailed illustration of a step of the flowchart of Figure 6 in accordance with the present invention.

10           Figure 14 is an illustration of an overlap detection of images in accordance with the present invention.

Figure 15 is a flowchart of the overlap detection shown on Figure 14.

15           The present invention will be described in connection with a preferred embodiment; however, it will be understood that there is no intent to limit the invention to the embodiments described. On the contrary, the intent is to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

### **DESCRIPTION OF THE PREFERRED EMBODIMENT**

20           For a general understanding of the present invention, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements. In describing the present invention, the following term(s) have been used in the description.

25           ~~The term "data" refers herein to physical signals that indicate or include information. When an item of data can indicate one of a number of possible alternatives, the item of data has one of a number of "values." For example, a binary item of data, also referred to as a "bit," has one of two values, interchangeably referred to as "1" and "0" or "ON" and "OFF" or "high" and "low." A bit is an "inverse" of another bit if the two bits have different values. An N-bit item of data has one of  $2^N$  values. A "multi-bit" item of data is~~  
30           ~~an item of data that includes more than one bit.~~

"Memory circuitry" or "memory" is any circuitry that can store data, and may include local and remote memory and input/output devices. Examples include semiconductor ROMs, RAMs, and storage medium access devices with data storage media that they can access. A "memory cell" is  
5 memory circuitry that can store a single unit of data, such as a bit or other n-array digit or an analog value.

A signal "indicates" or "selects" one of a set of alternatives if the signal causes the indicated one of the set of alternatives to occur. For example, a signal can indicate one bit set in a sequence of bit sets to be used  
10 in an operation, in which case the signal causes the indicated bit set to be used in the operation.

An image may include characters, words, and text as well as other features such as graphics. A text may be included in a set of one or more images, such as in images of the pages of a document. An image may be  
15 processed so as to identify specific within the image, each of which is an image.

A "bin" is a list of edge points that are approximately collinear. A list of edge points is converted into a sequence of bins that represent the boundaries as straight lines.

An object may be of any size and shape and has "physical attributes" or characteristics including, but not limited, to position, shape and orientation. For example, an object may be a document, when the document is placed on the platen of an image input device and the region of the platen is digitized to produce a representation thereof.  
20

An item of data "defines" an image when the item of data includes sufficient information to produce the image. For example, a two-dimensional array can define all or any part of an image, with each item of data in the array providing a value indicating the color of a respective location of the image.  
25

An item of data "defines" an image set when the item of data  
30 includes sufficient information to produce all the images in the set.



Each location in an image may be called a "pixel." In an array defining an image in which each item of data provides a value, each value indicating the color of a location may be called a "pixel value". Each pixel value is a bit in a "binary form" of an image, a gray scale value in a "gray scale form" of an image, or a set of color space coordinates in a "color coordinate form" of an image, the binary form, gray scale form, and color coordinate form each being a two-dimensional array defining an image.

An operation performs "image processing" when it operates on an item of data that relates to part of an image.

Pixels are "neighbors" or "neighboring" within an image when there are no other pixels between them and they meet an appropriate criterion for neighboring. If the pixels are rectangular and appear in rows and columns within a two-dimensional image, each pixel may have 4 or 8 neighboring pixels, depending on the criterion used.

An "edge" occurs in an image when two neighboring pixels have sufficiently different pixel values according to an appropriate criterion for the occurrence of an edge between them. The terms "edge pixel" or "boundary pixel" may be applied to one or both of two neighboring pixels between which an edge occurs.

An "image characteristic" or "characteristic" is a measurable attribute of an image. An operation can "measure" a characteristic by producing data indicating the characteristic using data defining an image. A characteristic is measured "for an image" if the characteristic is measured in a manner that is likely to produce approximately the same result each time it occurs.

A "version" of a first image is a second image produced using an item of data defining the first image. The second image may be identical to the first image, or it may be modified by loss of resolution, by changing the data defining the first image, or by other processes that results in modifying pixel values of the first image.

An "image input device" is a device that can receive an image and provide an item of data defining a version of the image. A "scanner" is an image input device that receives an image by a scanning operation, such as by scanning a document. A scanner may have a transparent surface (platen) or equivalent means to support a document during scanning. Other well-known image input devices include digital cameras, facsimile machines, and video recorders, or any image storage device having the capability to store data signals representative of the intensity of light reflected from the surface of objects at which the device is directed. A general purpose computer with an image creation program may also be an image input device.

An "image output device" is a device that can receive an item of data defining an image and provide or render the image as output. A "display" is an image output device that provides the output image in human viewable form, and a "printer" is an image output device that renders the output image in a human viewable, hard copy form.

Referring now to Figures 1 and 2, depicted therein is a digital printing system 20 in which the present invention finds particular use.

For example, system 20 may be a Xerox DocuColor® 40 Digital Color Printing System or the Xerox 5775® Digital Color Copier. System 20 includes a computer or data processing unit 22 (Figure 2) capable of receiving digital data representing an image of an original document 24 placed upon a platen of scanner 26. Computer 22 initially stores the digital input data from scanner 26 in memory 52 (e.g., RAM or magnetic disk storage) where the image may subsequently be accessed. In addition to the digital data, memory 52 may also include program memory for the storage of object code suitable for directing the processor to execute image processing operations in accordance with the invention described herein. Computer 22 has associated therewith a user interface (U/I) 28 including one or more user input devices 30, such as a keyboard, a keypad, a mouse, trackball, stylus or equivalent pointing device, etc.

Also part of system 20 is a color image output device such as printer 34 which may include a laser-driven, xerographic printing engine as found in a number of commercially available printers. In a preferred embodiment, system 20 is employed to process the digital image data received as input from a scanner 26, utilizing image processing software running in processor 50, so as to produce an output file that may be rendered by printer 34, stored in memory 50, and/or transmitted to another device via network 40. Although system 20 is depicted as an integrated unit in Figure 1, it will be appreciated that the system may also comprise a plurality of independent yet interconnected units. Referring to Figure 3, it will be appreciated that the document placed upon the scanner platen in system 20 may not be accurately registered along the registration edges 25. For example, a particular embodiment to which the following description will be directed is a single document object O placed in a central location on the platen of scanner 26 as illustrated in Figure 3. In accordance with the present invention it is desired to automatically identify the position, shape and rotation angle of object O. In a facsimile transmission system using a set of rollers to advance a document through a scanning nip, it will be appreciated that the document may become skewed during the digitization process and that the present application may have particular application to such systems as well.

Given an input image generated by scanning the scanner platen, the present invention automatically identifies at least the position, shape and orientation angle of the object. As shown in the flow chart of Figure 4, the process carried out by computer 22 during the processing of the input image includes three general steps. First, at step 100 the object within the image is located and boundaries of the object are generally identified. Once the object is located, the shape of the object is modeled at step 200. Having located the object and modeled its shape, a structured image or similar digital document format representing the image and the object therein can be created as represented by step 300. The structured image preferably includes data

representing not only the image data itself, but data representing the location, shape or orientation of the object, or some combination thereof. Alternatively, the output may be a page description language format or equivalent formats suitable for storing the image information in a retrievable form.

5 In an embodiment of the present invention, the scanned input image (or a lower resolution version thereof) is loaded into a memory frame buffer (RAM) where it is analyzed in accordance with the previously described steps. For purposes of the following detailed description, it is assumed that the object is distinguishable from the image background (e.g., the platen cover)  
10 and that the background of the image is contiguous. These simplifying assumptions are intended for purposes of explanation only and are not intended as limitations of the invention. One skilled in the art will appreciate that the invention described herein is extensible so as not to require operation only within the boundaries of such assumptions.

15 ~~As depicted by the flowcharts of Figures 5 and 6, the object~~  
location step 100 is performed by first identifying the background region of the input image 102, characterizing the background region 104, and then using the characteristic of the background region as a seed, identifying all the pixels representing the background region with an adaptive seed fill algorithm 106.  
20 Background pixels are pixels not associated with any objects, or more simply, they are pixels representative of those regions lying outside of the objects, the values of which are controlled by the "background" against which the objects are placed during scanning (e.g., the underside of the platen cover). One embodiment employs the average color of a small region in the upper left-hand  
25 corner of the scanned image as an initial estimate of the background color. Alternatively, other sampling operations may be employed to determine the background color as described, for example, in US-A-5, 282,091 for a Programmable Apparatus for Determining Document Background Level by Farrell.

Once the background color is characterized at step 104, an adaptive algorithm is preferably applied to monitor the background color and to accurately identify the objects. An example of a seed fill algorithm suitable for use in the present invention is described in Graphics Gems I, A. Glassner Ed., Academic Press, pp. 275-277, 1990, hereby incorporated by reference. An adaptive algorithm is required because the background pixels may have significant color variation resulting from a variation in illumination over the platen area. The adaptive seed fill algorithm is applied to the scanned color image data using an initial seed point characterized by the background, for example, the upper-left corner of the image. Generally, the adaptive seed fill algorithm fills a binary frame buffer with a mask indicating all contiguous pixels identified as background pixels. In a simple embodiment, represented by step 112, a pixel is considered to be a background pixel if its color falls within a small distance  $\epsilon$  of the current average background pixel value. This distance is calculated as an Euclidean metric in red, green, blue (RGB) color space

$$d = \text{SQRT} \left( (P_r - \text{AdAvg}_r)^2 + (P_g - \text{AdAvg}_g)^2 + (P_b - \text{AdAvg}_b)^2 \right),$$

where  $P_k$ ,  $\text{AdAvg}_k$  are, respectively, the RGB components of the pixel under test and the average background value, and  $d$  is the distance measurement. The value of  $\epsilon$  is fixed and empirically determined in one embodiment. The test conducted at step 112 is:

if  $d < \epsilon$ , then pixel P is a background pixel, else pixel P is a foreground pixel.

The average background color is adaptively modified at step 114 by taking the average value of the last N pixels that have been classified as background. For efficiency, the system preferably calculates the adaptive average using the equation:

$$\text{AdAvg}' = (N * \text{AdAvg} - \text{AdAvg} + \text{LastVal}) / N,$$

where  $\text{AdAvg}'$  is the modified average,  $\text{AdAvg}$  is the previous adaptive average,  $\text{LastVal}$  is the value of the last pixel identified as background, and N

is the averaging window. Clearly, this is not a true running average, but it tracks the running average adequately and is more computationally efficient than a strict running average calculation. Alternatively, the value of  $\epsilon$  can be adaptively modified. For example,  $\epsilon$  might be based on the standard deviation of the last several pixels identified as background, etc.

It will be appreciated that alternative methods for the detection of background regions may be employed, and that the process of obtaining a binary map distinguishing the objects from the background may be accomplished using a simplified thresholding operation based upon the background color. In a preferred embodiment, the background color may be a function of the color of the platen cover, such as a white cover. As a further example, the digital color production system may employ a spectrally reflective or otherwise distinguishable platen cover that results in a background color that may be detected and distinguished from the objects.

Having identified background pixels and created a representation of the object boundaries, noisy edges can be optionally smoothed using, for example, morphological filtering. Subsequently, contiguous foreground regions are located, step 122, thereby identifying the objects. Scanning the background mask generated by the adaptive seed fill operation (step 106) identifies objects. Starting with the upper left hand pixel, the mask is searched in a scan line fashion for a pixel not classified in the mask as a background pixel - thus identifying pixels associated with a foreground object. The use of the seed fill algorithm for identifying the background assures that foreground objects are closed, or in other words, a complete boundary is formed about the perimeter of the object.

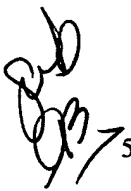
At step 124, tracing its edge identifies the boundary of an object. The boundary of the foreground object is traced using a simple 8-connected edge traversal operator which provides an ordered-set of points tracing the edge of the object. Such an edge traversal operation employs a contour tracing operation to generate a chain code in a manner similar to word or character


based recognition systems. R. Bozinovic et al. in "Off-Line Cursive Script Word Recognition", IEEE Transactions describes an 8-connected process, for example, on *Pattern Analysis and Machine Intelligence*, Vol. 11, No. 1 (January 1989). In the situation of detecting multiple objects, one main object would  
5 preferably be selected using any of a number of techniques. For example, object selection could be accomplished by retaining the object with the largest perimeter or based upon the location of the object.

Once the object has been located, as described with respect to step 100, the next general step, step 200, is to model the shape of the object.

10 For purposes of simplicity, the following description will treat rectangular-shaped objects, however, it will be appreciated that the description of the invention is extensible to other polygons and even to shapes having portions thereof represented by curves (e.g., circular or elliptical objects). The result or output from step 100 is a set of bounding pixels or a set of edge traces  
15 preferably organized in the form of a linked list. These pixels or traces can be used to extract the object, but orientation is not yet determined. To improve the quality of the object extraction, the object traces are fitted to a model shape. Orientation information and other characteristics of the object may then be extracted from the fitted parameters.


20 At step 400 of Figure 7, the 'bin' or result of step 100 i.e. the step of bounding pixels or set of edge traces in the form of a linked list is defined. At step 410, a reduction of the data set is necessary. The linked list defined at step 400 may be too large; in fact, it may be in the order of 1,000 data points or more. Therefore, it is necessary to reduce the amount of data of these 1,000  
25 or so data points. Using a factor N divisible into the total data points does such data reduction is performed. Typically the factor is around the value of 5, or may be another factor that enables a 100-200 point's border. For example, if there were 1,000 data points, to reduce such a data set to within 100-200 points would require a factor between 5 and 10. The data set is then reduced  
30 to a set of 100-200 points.

5  After the data reduction, at step 420 of Figure 6, an estimation of the angle of the line passing through each remaining point on the contour is preformed. As shown in Figure 7, a modified linear regression in a particular window (W) centered on each point is performed so as to estimate an angle of the line passing through each remaining point of the contour determined by the set of data points. Initially a modified linear regression is done on a small window centered on a point (A) where each linear regression requires a series of additions, multiplication's, and arc tangent calculations.

10  In particular, ~~a standard regression algorithm fits data to the line~~  $y=mx+k$ . However, using a standard regression algorithm to perform these functions can lead to erratic results as the line approaches a vertical. Therefore, in the present invention, the algorithm is modified so as to account for these erratic results. As shown in Figure 8 in each of the four quadrants indicated therein, a standard regression is used for the lines that are more  
15 horizontal in two quadrants with a slope between  $-45^\circ$  and  $+45^\circ$ . When the slope is not in the identified degrees, that is, when the lines are more vertical with a slope greater than  $45^\circ$  and in the other two quadrants, an inverted linear regression based on the inverted linear equations  $x=1/ny-k/m$  is performed. The slope angle is determined from the following equations:

20  $| \text{avg}(xy) - \text{avg}(x)\text{avg}(y) | > | \text{avg}(x^2) - \text{avg}(x)^2 |$  when the slope is more vertical

$| \text{avg}(xy) - \text{avg}(x)\text{avg}(y) | < | \text{avg}(x^2) - \text{avg}(x)^2 |$  when the slope is more horizontal

25 Once the slope calculation are accomplished, at step 430 of figure 6, each point associated with an angle is categorized by performing a bin categorizing operation to generate a series of bins. For example, as shown in Figure 9, bins B1, B2, B3, and B4... are generated from a series of angles, which are associated with each point. The object of step 430 is to categorize  
30 



groups of adjacent boundary points that share a common slope, i.e. convert the list of boundary points into a sequence of bins (B1, B2, B3...) where each of the bins consists of a set of collinear points so as to generate a boundary of an image made up of a set of straight line segments.

5 When generating the above-described line segments, boundary point angles of the predecessor points may differ from the angle of the current point by a substantial amount. If, for example, the boundary point' angle differs from the previous point by less than a particular amount E, then the point is added to the current bin. If the boundary point angle differs by more than a particular amount E, then it is assigned to a new bin. Each bin (B1, B2, B3...) represents a set of collinear points along the edge.

15 Once the bin categorization is completed and the each point is assigned with the appropriate bin some of the bins contain categorized contain to few data points. Therefore at step 440 of figure 7 it is necessary to remove the bins which contain few or less than a minimum number of data points. Typically this removal is performed when there are approximately 5 data points. As an example of this removal in Figure 10, the smaller bins A, B, and C are removed because they contain less than 5 data points.

20 After the bin removal of the smaller bins, an average angle of points within each of the remaining bins is determined at step 450. The same modified regressions described above are now applied to the remaining bins generating an average slope and average slope angle calculation for each of the remaining bins.

25 Next, the remaining bins that share common angles are combined at step 460. These remaining bins were previously not adjacent to each other but became adjacent at step 440 by the removal of small bins found in between the non-adjacent bins. When these bins in between are removed, the bins that are left and that are now adjacent can sometimes be collinear. Therefore, the angle of each bin is checked and if adjacent bins are collinear, 30 the bins are joined into a single bin at step 460. Such a procedure is

illustrated in Figure 11, were a bin defined by AL-AR and another bin defined by BL-BR are compared to each other. The midpoint between each point AM/BM is calculated and the slope of the segment AB is determined and compared to the slopes of each of the bins. If the slopes are within 10°, an amount designated as E, then the following calculation is performed.

(Slope (AB) - Slope (A)) < E & (Slope(AB) - Slope(B)) < E where E is approximately 10 degrees. There are instances when the slope calculations are susceptible to noise in short bins, hence the value is modified if one of the bins is determined to be very short with respect to the other bin.

Finally, at step 470, the intersection between each bin and the next bin is calculated. The midpoint x, y, and slope angle M of each bid is used to calculate the intersection xy between the two bins.

$$k_1 = y_1 - m_1 x_1$$

$$k_2 = y_2 - m_2 x_2$$

$$x = (k_2 - k_1) / (m_1 - m_2)$$

$$y = m_1 x + k_1$$

The angle of intersection is calculated from the vector cross product between vectors pointing from the intersection point to the midpoints:

$$A \times B = [(x_1 - x)(y_2 - y) - (x_2 - x)(y_1 - y)] k$$

$$= [A] [B] \sin (\theta) k$$

$$\theta = \sin^{-1} \{[(x_1 - x)(y_2 - y) - (x_2 - x)(y_1 - y)] / [A] [B] k\}$$

At this stage of the procedure the edge boundary has been reduced to a small number of bins. The next step is to apply a recognition algorithm because the final number of bins usually is 4 for rectangular images.

However, there are cases when there are more than 4 rectangular images and so it is necessary to apply a recognition algorithm. This results because smart platens sometimes have regions that are always easily distinguished from the background images and the boundaries of the detected images bleed into the background images. Because of the bleeding, the detected boundaries do not match the actual images in certain locations. Therefore, the boundaries fail to

fit the actual image and it is necessary to apply further procedures to make the boundaries fit particular images.

At step 500 of figure 12, the list of bins which is generated is browsed to identify bins that have 90° intersections with neighboring bins or the bins that approximate 90° angles with their neighbors. If there are bins that are ascertained to be at 90° angles, then these bins are overlooked because often the bins that have these angles are from images misaligned against the edges of the platen. Therefore, if the bin is found to be a right angle then the bin is more than likely generated from images aligned at platen edge and accordingly should be discarded. Moreover, it is necessary to search for all right or 90° angles because these angles also may correspond to the corners of an image. To be considered a right angle a bin has to lie between 85-95°. As indicated earlier, in step 470 of Figure 7 the angle of intersection is calculated and is used in step 500 to determine whether or not there are right angles.

Next, as illustrated in Figure 12, at step 530, once the right angle is identified, the flow proceeds to determine whether a rectangle can be constructed and can be test fitted to the boundary. To construct a rectangle the following steps shown in the flow chart of Figure 13 are performed.

At step 700 of figure 13, an estimation of the rotation angle of a rectangle as the slope angle of the right angle of the bin is performed. Next, at step 710 all the points on the boundary of the rectangle are rotated according to the rotation angle found in step 700. At step 720, the axis aligned bounding box is calculated. Then the corner coordinates of the axis aligned bounding box are unrotated at step 730. The flow then proceeds to step 540 of figure 12.

At step 540 of figure 12, a test of the similarity measure or similarity fit is performed by counting the number of boundary points in each of the two bins that are at right angles and that lie within a measure of 3 pixels of the resulting bounding box divided by the total number of points in the bin. If

the similarity measure is less than .9 the rectangle test is considered to be a good match and the flow proceeds until done. If the similarity test is less than .9 no results are found the flow proceeds to step 500 for the next pair of bins at step 545 and is repeated for the next right angle pair of bins. If no angles  
5 have similarity then the flow proceeds to step 550 to an after final search until no bins are left.

Next, at step 560 the longest bin is searched and the flow proceeds to determine if a rectangle can be constructed to be test fitted to the boundary. In order to construct the rectangle the following steps are  
10 necessary as shown in Figure 13. Initially, an estimation of the rotation or angle is determined at step 700, then all the points are rotated at step 710, a calculation of an axis aligned bounding box at step 720 and the corner coordinates of the axis-aligned bounding box are unrotated. The flow then proceeds to step 580. There a rectangular test fit is performed and is  
15 determined to be good if the test fit similarity measure is greater than .9 resulting in a good match to be determined. If the similarity measure is less than .9 the flow proceeds back to step 560 and is repeated again for the next longest bin. If the test fit similarity test fails again then the step proceeds to the after final search with no bins left Step 600. The flow then proceeds to Step  
20 610 where the longest bin is searched. Then a rectangle is constructed at step 620 from the longest bin.

At this point, a bounding box has been identified along with its rotation angle. The next step is to eliminate those boundaries that are determined not to actual boundaries of the bounding box. If the aspect ratio of  
25 the bounding rectangle is more than 15:1 or less than 0.075:1 then a boundary is considered not to be conforming as a boundary of the bounding box and is rejected. Also, if the actual width or height is less than 5 pixels; the boundary is again considered not to be desirable and is rejected.

Finally, it is possible that a single image may show up as two or  
30 more boundaries if the bleeding is excessive. In this case, a containment

algorithm is applied to test if a boundary is contained within another. Each boundary is tested against all other boundaries to see if there is a 25% or more overlap between the two boundaries. If such an overlap occurs, the two boundaries are joined and the bounding rectangle is recalculated (go to step 500).

The points that make up a boundary are generally the verticals of a many-sided polygon. The containment test as shown in figure 14, is a procedure to calculate the overlap between two polygons P1 and P2.

Initially, as shown in figure 15, a determination of the minimum and maximum P1 & P2 y-values (step 800) for each polygon is performed. In the case of Smart Platen, these values are already known and do not have to be recalculated. Next, for each polygon, there is an allocation of an array large enough to store two integers for all possible values of y in the polygon (step 810). For example, if y were to have a range of 332, then it is necessary to allocate an array of 332 pointers to two integers. Third, for each polygon, X values are determined by scanning through the vertices and determining the min and max values of X for each Y-value (step 820). However, vertices may not exist for each y-value, therefore Y-values may have to be interpolated. As an example, consider two vertices given by (x1,y1) and (x2,y2) where  $y_2 - y_1 = K$ . It is necessary to interpolate K-1 values of X, one for each value of y. The algorithm for interpolating x is as follows:

(Step 830)

$dx = (x_2 - x_1) / K;$

for (j=0; j<K; ++j)

{

$x = x_1 + j * dx;$

...

}

Once the arrays containing the min and max x-values for each polygon is created at step 810, an overlap measurement determination is performed at step 840.

The test for vertical overlap is if the least y-value is greater than the largest y-value step 840, there is no overlap and then the flow proceeds to step 880. Also, if the largest y-value of P<sub>1</sub> is less than the least Y-value of P<sub>2</sub>, then there is no overlap, the flow proceeds to step 800. However, for those y-values where both P<sub>1</sub> and P<sub>2</sub> overlap, the horizontal overlap is summed and the following checks are performed. First, if the minimum x-value of P<sub>1</sub> is greater than the maximum x-value of P<sub>2</sub> then the flow proceeds to step 860. Second, if the maximum x-value of P<sub>1</sub> is less than the minimum x-value of P<sub>2</sub>, then the flow proceeds to step 870 and an estimation of the overlap for that y-value is performed as follows:

15 ~~Overlap = Maximum (P<sub>1</sub><sub>xmin</sub>, P<sub>2</sub><sub>xmin</sub>) - Minimum (P<sub>1</sub><sub>xmax</sub>, P<sub>2</sub><sub>xmax</sub>) + 1 (step 870)~~

This determination shown above returns the overlap between two polygons. When applied to the inventions platen, we normalize the returned overlap area by dividing by the smaller of the two borders. If the result exceeds 25%, the smaller boundary is considered to be an orphan or a part of the larger boundary and the two are merged and a new bounding rectangle is calculated.

By performing the above steps a good bounding rectangle is identified. Further techniques such as file extraction are also applicable to further process the received data. Other kinds of processing steps may also be performed for detecting non-rectangular objects, overlapping rectangular objects, etc.

While the invention is described with reference to a particular embodiment, this particular embodiment is intended to be illustrative, not limiting. Various modifications may be made without departing from the spirit and scope of the invention as defined in the amended claims. Modifications

